CHAPTER 4

IMPLEMENTATION GUIDANCE FOR MATERIAL CONDITION AND AGING MANAGEMENT

This guidance is appropriate for high-hazard facilities expected to operate for an extended period. Since DOE facilities vary in hazard level and circumstances of operation, a graded approach to implementation should be adopted.

As shown in Figure 4–1, Material Condition and Aging Management (MCA) activities are developed and implemented in three distinct phases: a preliminary phase, a detailed or main phase, and an ongoing phase. The preliminary MCA phase includes activities necessary to estimate the facility remaining lifetime and to develop the MCA program plan. The detailed MCA phase builds on the preliminary estimate of facility remaining lifetime with more rigorous evaluations of aging degradation mechanisms to determine more precisely the remaining lifetime. The detailed MCA phase also identifies life extension techniques, if the facility desired lifetime is greater than the remaining lifetime. The ongoing MCA phase identifies degradation measurements to be performed periodically for life-limiting components, performs trending analyses on the results of those measurements to predict the end of life, and implements any necessary life extension techniques. The results of the MCA activities are reviewed by the design authority to determine whether there are new design requirements that should be integrated into the ongoing configuration management (CM) program efforts.

4.1 PRELIMINARY MCA PHASE

The preliminary MCA phase has two primary objectives: (1) to develop a preliminary estimate of the facility remaining lifetime and (2) to develop an appropriate MCA program plan.

4.1.1 COMPONENT SCREENING

Some components are so expensive or difficult to replace that their failure may limit the life of the facility. The first activity in the preliminary MCA phase is to screen all components associated with the facility, both active and passive (e.g., structural) components, to identify potentially life-limiting components. They are to be categorized as mission structures, systems, and components (SSCs) if they do not warrant a higher category and are to be addressed in the overall CM program.

The first step is to identify all components associated with the facility, both active components and passive components, including structural components. A typical facility may encompass hundreds, even thousands, of individual components. To provide reasonable assurance that all facility components are considered and none are inadvertently overlooked, the preferred approach is to use a Master Equipment List (MEL) if the facility has one. If not, the best available information should be used, such as maintenance records, system design descriptions (if they exist), and engineering drawings.

The next step is a review of these facility components by experienced personnel who have a detailed knowledge of the facility and who can identify those components whose failure would have a major cost, safety, or programmatic impact on the facility. This phase of the MCA program excludes components that can be repaired or replaced. After consideration of several hundred components, a small number (perhaps a dozen) are likely to emerge as potentially life-limiting for the facility.

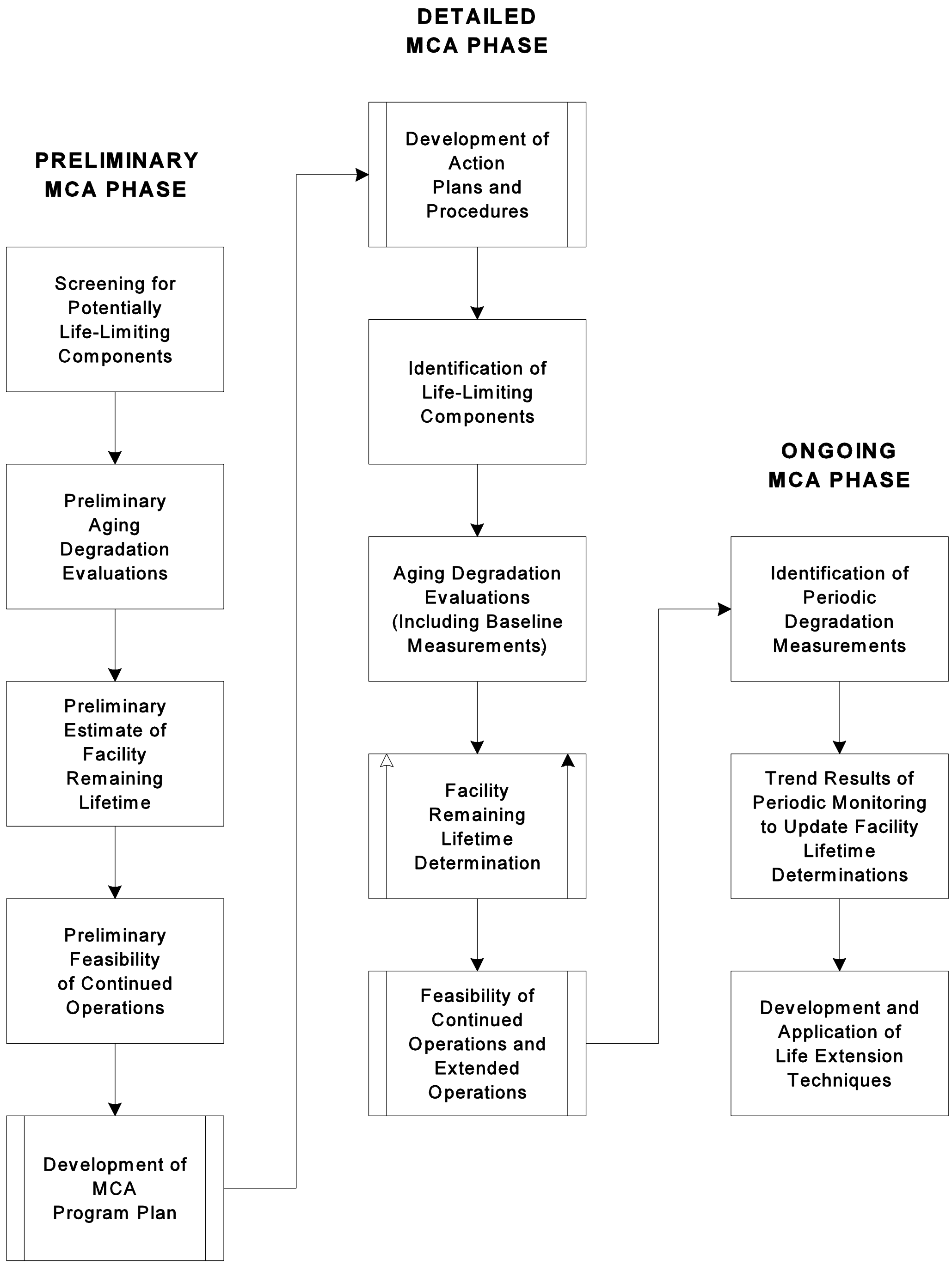


Figure 4-1. MCA Implementation Process

4.1.2 AGING DEGRADATION MECHANISM EVALUATIONS

During the preliminary MCA phase, the major aging degradation mechanisms are identified for each potentially life-limiting component. These mechanisms vary for different types of components, but may include fatigue, corrosion/erosion, stress corrosion cracking, and irradiation. This preliminary evaluation is not intended to be a thorough analysis of all aging stressors, their effects, and failure modes. Rather, it is to be based on available data, initial inspections, and engineering judgment.

To provide a basis for an estimate of the facility's remaining lifetime, the current material condition of the components is determined. The aging degradation mechanisms most likely to cause -failure should be emphasized, and any previous aging evaluations that have been performed should be used in this process. Walkdowns may be useful for visually identifying unexpected degradation, and interviews with cognizant personnel from the operations, maintenance, and systems engineering organizations may provide insight into the current material condition of each component. In addition, senior facility personnel who were involved in the construction and initial operation of the facility may be able to provide useful information regarding historical perspectives, operating practices, maintenance practices, and previous findings and conditions.

4.1.3 ESTIMATION OF FACILITY REMAINING LIFETIME

The preliminary estimate of a facility's remaining lifetime is not expected to be precise; rather, it should place components in lifetime categories: 0-2 years, 2-5 years, 5-10 years, and more than 1 0 years. Unless better information is available, it should be presumed that the stresses on the potentially life-limiting components involved In operations and operating environments will be the same in the future as in the past.

The estimated remaining lifetime of the facility equals the shortest of the estimated remaining lifetime of the facility's potentially life-limiting components, provided that life extension techniques are not applied. The facility remaining lifetime should be estimated conservatively to compensate for the uncertainties involved. To ensure that users of the estimated remaining lifetime have some understanding of its accuracy limitations, the amount of uncertainty involved in the remaining lifetime should be estimated using engineering judgment.

4.1.4 FEASIBILITY OF CONTINUED OPERATIONS AND EXTENDED OPERATIONS

Only in certain situations are the feasibility of continued operations and the feasibility of extended operations addressed during the preliminary MCA phase. The feasibility of continued operations should be addressed when the preliminary estimate of facility remaining lifetime is very short and there may be questions about the advisability of continuing operations at all. The feasibility of extended operations should be addressed (1) when the estimated remaining lifetime is less than the DOE desired lifetime, and (2) when the desired lifetime is comparable to the remaining lifetime, due to the uncertainties expected to be involved in the estimates.

These feasibility studies involve (1) identifying management alternatives for continued operations or extended operations, (2) estimating the costs for each alternative as a function of time, and (3) developing recommendations regarding facility continued and extended operations. Management alternatives may include the following: operate the facility until the end of its estimated remaining lifetime; develop and apply facility life extension techniques when the desired lifetime is greater than the estimated remaining lifetime; or place the facility in a standby mode at a specified time, in anticipation of future operations. Cost estimates for each alternative need not be precise, but they should indicate where significant changes in costs would occur. Recommendations regarding continued operations and extended operations should take into account not only the cost factors, but also the safety and programmatic mission of the facility.

4.1.5 MCA PROGRAM PLAN

Although part of the CM program plan, the MCA program plan may be provided separately and should be a stand-alone document. It should be prepared in accordance with directions set forth by the facility CM program to address the topics identified in program criterion 1.3.1.1.c.

The amount of useful information available for the MCA program, which includes design requirements and operations/maintenance history Information, will vary significantly. The CM program initial assessments may provide some insight into the availability and quality of existing MCA-type information. The MCA program plan should reflect the availability and quality of this type of information.

The MCA program plan should identify programmatic and organizational interfaces with other CM program elements, the facility maintenance program, and the organization responsible for facility design (i.e., the design authority). The programmatic interface with the design requirements program element is particularly important because design life, design operating conditions, and performance, characteristics are specified through design requirements. The organizational interface with the design authority is also particularly important to the MCA program since the products of the MCA, program (e.g., recommended periodic monitoring, revised operating/ environmental conditions, and improved maintenance) are provided to the design authority as proposed new design requirements.

In some cases, the estimated facility remaining lifetime may be substantially longer than the desired lifetime, eliminating the need for additional MCA activities. If proceeding with the MCA program beyond the preliminary phase is not appropriate, the program plan should address those circumstances that define the appropriate level of implementation.

4.2 DETAILED MCA PHASE

The detailed or main phase of the MCA program involves the development of an action plan and supporting procedures, final identification of life-limiting components of the facility, final evaluations of aging degradation mechanisms, determination of facility remaining lifetime, identification of life extension techniques, and feasibility of continued operations and extended operations.

4.2.1 MCA ACTION PLAN AND PROCEDURES

The contractor should develop an action plan, governing procedures, and implementing procedures, as described in section 2.1.4.

4.2.1.1 MCA Action Plan

Within approximately 6 months after DOE review of the MCA program plan, the MCA action plan should be completed. It should identify the program manager and project organization, provide a clear mandate, and have the support of senior management. The contractor should participate directly in the development of the action plan to ensure ownership, knowledge retention, achievement of purpose, and ongoing and effective MCA. All affected parties should concur with the plan.

The action plan should describe the review and approval process for project deliverables and should identify end users. Early input and feedback from end users is crucial in the effort to realize the MCA program objectives. The MCA team should include representatives of the end users, as well as representatives of the engineering, operations, and maintenance departments. Proper selection of the MCA team is vital to success.

The collection of information or data and the performance of MCA evaluations will likely be accomplished in several iterations. Information developed or conclusions reached at a given point in the program may invalidate prior information or conclusions, or it may indicate that more detail or additional information is necessary. Data gathering may occur in stages as the aging evaluations indicate the need for more data. Sources of information or data used to support the conclusions should be documented.

Initially, the action plan should provide the greatest detail for those activities that need to be completed in the near term. Moreover, the action plan should provide detailed discussions of those activities that have already been completed. The MCA action plan may be revised and updated as the program progresses.

4.2.1.2 MCA Governing and Implementing Procedures

The contractor should develop governing and implementing procedures for the MCA adjunct program. Governing procedures serve to indicate the correlation of the action plan with the program plan and to coordinate the implementing procedures with each other and with the action plan. Governing procedures are, in effect, an umbrella document or overview of the implementation process.

Development of facility implementing procedures to support the action plan is necessary to ensure a consistent approach to MCA and to promote the successful and cost-effective completion of the MCA program. These procedures should address and control responsibilities associated with the performance of analyses and with the preparation, review, and approval of documents. The procedures should provide specific methods for identification of life-limiting components, detailed aging degradation evaluations, determination of facility remaining lifetime, and feasibility for continued operations or life extension.

4.2.2 FINAL IDENTIFICATION OF LIFE-LIMITING COMPONENTS

The final list of life-limiting components should be developed through a structured process based on established criteria and a detailed scoring methodology. This list of components provides the subjects for the detailed MCA analysis. A flow diagram for the identification of life-limiting components is shown in Figure 4–2.

The primary activities of this process are:

- Screen SSCs to identify components that are potentially life-limiting.
- Determine significance to facility lifetime of potentially life-limiting components.
- Identify the life-limiting components.

Personnel knowledgeable about the facility and its safety analysis should perform the screening of SSCs to identify those components that are potentially life-limiting. These components should meet one or more of the following criteria:

- Replacement cost is large.
- Replacement schedule is long.
- Failure may have significant impact on facility safety.
- Known history of safety concern exists.
- Operating conditions or environment are relatively harsh.

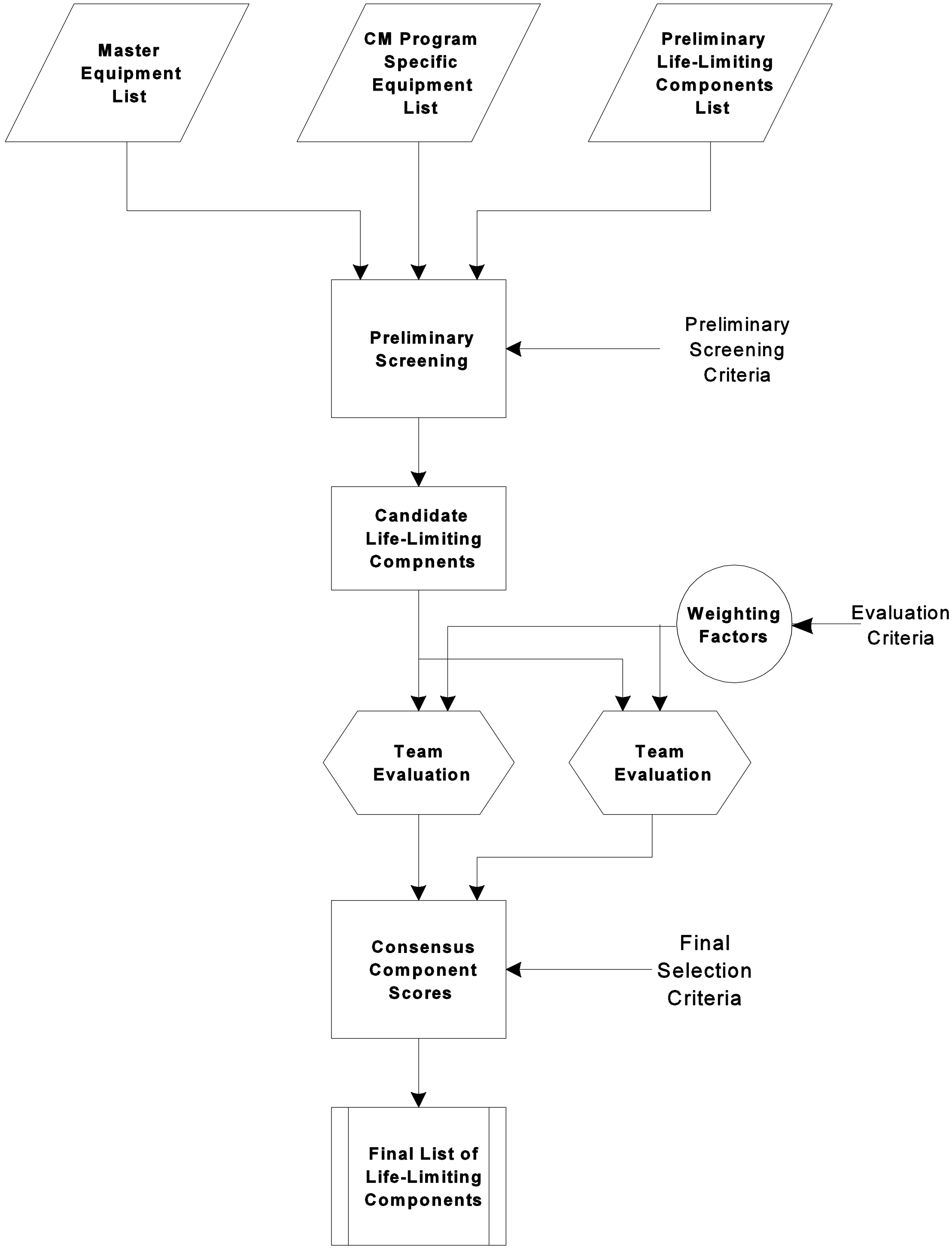


Figure 4-2. Final Identification of Life-Limiting Components

Life-limiting components are selected by applying predetermined evaluation criteria to the components that were identified as potentially life-limiting, with each component given a score for each criterion. The evaluation criteria should include consideration of:

- Feasibility of replacement
- Replacement schedule, including outage duration (facility downtime)
- Replacement cost
- Impact on adjacent structures
- Disposal and transportation difficulties
- Service environments (corrosion/erosion, dynamic loading, radiation, environmental conditions, and synergistic effects)
- Safety
- Issues that are specific to the facility

Each evaluation criterion should be assigned a weighting factor that is applied to its score, with the considerations that are most critical to facility life having the highest weighting factors. The combination of the score and the weighting factor determines the total score for each consideration. The total score for each potentially life-limiting component is the summation of the total scores for each consideration. This scoring is performed for each potentially life-limiting component.

Because the score that a component receives for each criterion depends on the knowledge and experience of the scorer, it is recommended that at least two teams perform the evaluations. These teams should consist of individuals who are experienced in the design and operations of the facility and who are supported by personnel trained or experienced with MCA. The teams should work independently during the initial scoring process. Subsequently, representatives from each team should meet to resolve differences and generate a consensus composite score for each component.

Once the scoring process has been completed, the final selection criteria for the life-limiting components may be a threshold value for the consensus composite score of a component or some other criterion that appropriately identifies life-limiting components.

Concurrent with this activity, SSCs within the CM program may be screened to identify SSCs that, although not life-limiting, should be reviewed in more detail to evaluate aging. A review of the non-life--limiting components may indicate that aging management should be adopted as a matter of good practice. If the failure of certain SSCs may have a significant impact on safety or mission, evaluation may be appropriate. Because of the potentially severe impact, it is desirable to avoid failure of some types of equipment. For example, a facility may have so many electrical cables and cable trays that special attention to them is warranted. Similarly, if a facility has several hundred motor-operated valves, this type of equipment may warrant special attention. This SSC review should be coordinated with other programs, such as the maintenance program.

4.2.3 DETAILED AGING DEGRADATION EVALUATIONS

The purpose of detailed aging degradation evaluations is twofold: (1) to identify mechanisms that determine the lifetime of components and (2) to provide for observations or measurements that define the condition of life-limiting components. This information is necessary to the final determination of facility remaining lifetime, the feasibility of continued operations, and the definition of the ongoing MCA program. This activity includes performing the following steps for each component:

- Develop full description of the component.
- Identify significant aging mechanisms.

- Identify measurements that will monitor significant aging effects.
- Make baseline measurements of component material condition.

The methodology, depicted In Figure 4–3, provides a model that may be used for both life-limiting components and important SSCs that are not life-limiting, but have been selected for detailed MCA analysis.

4.2.3.1 Component Description

The description of component parts, environment, and functions should be sufficiently detailed to permit the identification and evaluation of the significant stressors and aging mechanisms. The safety-, environmental-, or mission-related functions and operation of each component should be described in terms of design requirements. Components may have multiple functions that are either active or passive. Each component should be described in a way that makes clear the boundaries between what is being evaluated and what is not being evaluated. For example, the boundaries of a motor-operated valve may be at the welds or flanges that connect it to the piping system, at the electrical breaker that provides the electrical power to the motor operator, and at the connectors for the instrumentation and control circuits. In this case, the connecting piping, the electrical power distribution system, and the instrument and control system are outside the component boundary. Interfaces with other equipment and systems should be described relative to physical, design, and environmental factors. If the component was qualified for its application by special testing or analysis, the specific set of functional requirements and environmental conditions that comprise the qualification of the component should also be described.

Breaking down the component into subcomponents simplifies the task of identifying significant aging mechanisms and failure modes. Subcomponents are generally divided into those that have a similar identifiable importance to the overall function of the component/assembly and those that react to stressors in a similar manner. The breakdown of components into subcomponents often facilitates the aging degradation evaluations. For example, a battery can be divided into subcomponents consisting of the container, the plates, the terminals, and the electrolyte. Each has different aging mechanisms and failure modes. Evaluating each subcomponent separately is easier than evaluating the component as a unit.

4.2.3.2 Identification of Significant Aging Mechanisms

For each subcomponent, the stressors and aging mechanisms that could lead to failure should be identified. This process is shown in Figure 4–4. The descriptions of the components make it possible to identify the types of stresses and the materials that are affected by each stress. It is important to identify the degrading effects that the stresses have on the materials to help determine potential failure modes for the equipment. The Nuclear Regulatory Commission (NRC), the commercial nuclear industry, and industry standards organizations have performed a number of aging studies. That provide useful information concerning materials susceptible to aging, the stresses that cause them to degrade, and resulting degradation mechanisms. Examination of the component, its design, its functions, and pertinent aging mechanisms, as well as qualification, performance, maintenance, test, and condition--monitoring data may provide additional information. For example, excessive temperature is a stress to the insulation of electrical cables that can cause the insulation to become brittle and lose its integrity; the resulting failure modes are shorts to ground and shorts to other electrical circuits.

Evaluation of the potential aging stresses and the resulting failure modes that have the most significant effects on facility safety or availability takes into account the severity of the stresses found in the facility and the rate of progression, or aging rate, to identify each aging mechanism. The magnitude of stresses in the facility may already have been measured and documented in facility records, or

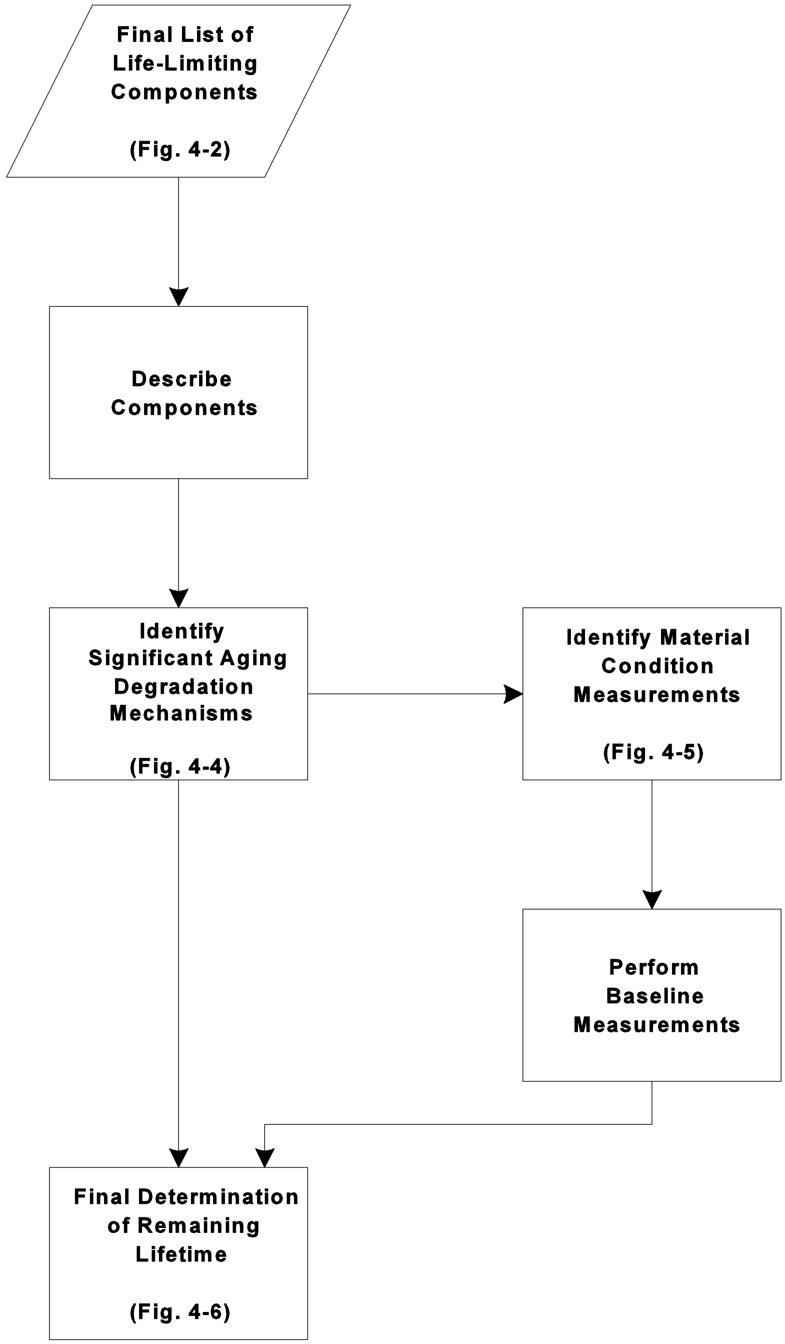


Figure 4-3. Detailed Aging Degradation Evaluations

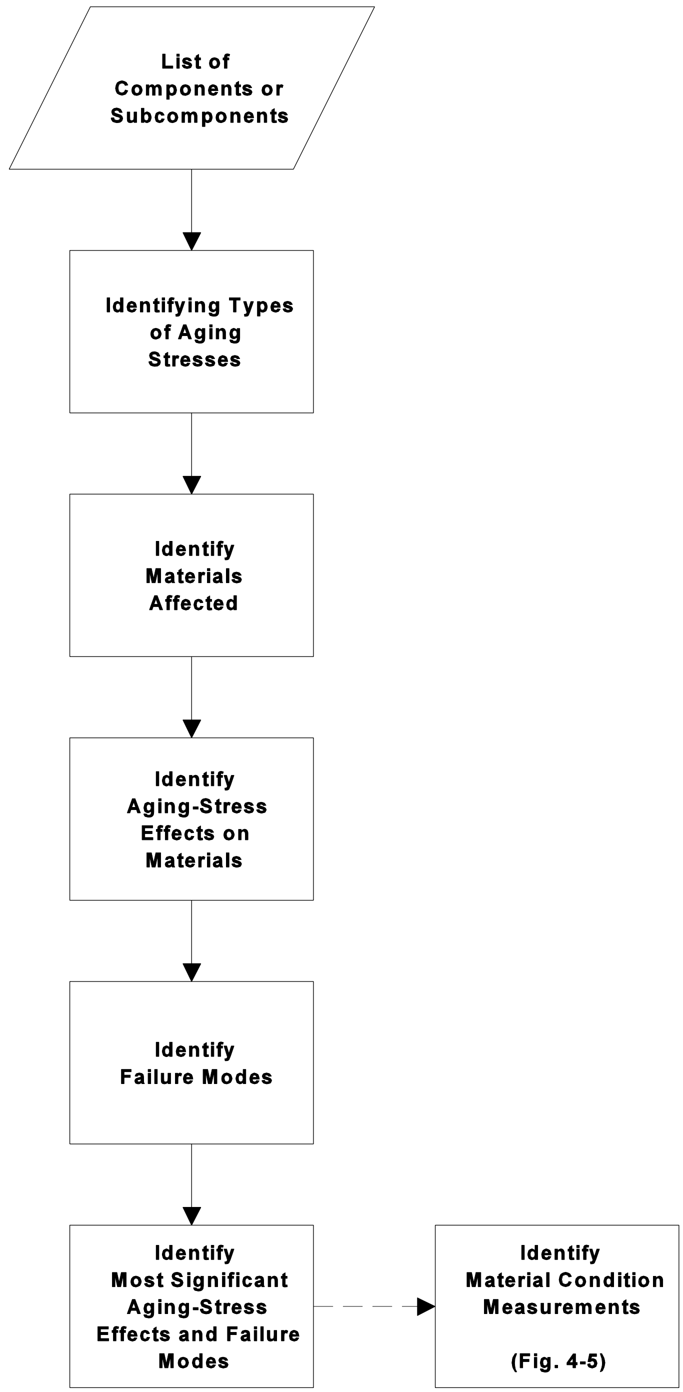


Figure 4-4. Identification of Aging Degradation Mechanisms

measurements may be taken specifically for this purpose. Failure modes and effects analyses (FMEAs) performed to support safe operation of the facility may be useful in identifying the failure modes that have the most safety significance. In addition, the selection of ongoing maintenance tasks for the component may have been based on actual experience and similar evaluations of the ways in which significant failures could occur.

4.2.3.3 Identification of Material Condition Measurements

Practical measurements should be identified to monitor significant aging effects. As shown in Figure 4–5, the first step is to identify the physical characteristics associated with each significant failure mode and corresponding aging mechanism. The emphasis should be on the physical characteristics associated with stressors and aging mechanisms that have the most significant influence on a failure mode (i.e., component or material properties most affected by the aging mechanism). Material characteristics (e.g., hardness or dimensions) and electrical characteristics (e.g., electrical insulation integrity) are examples of critical physical characteristics.

The next step is to identify the actual parameters to be measured or monitored for detecting the presence and rate of degradation in a critical physical characteristic. To the extent possible, these parameters should be direct measurements or observations of the previously identified critical physical characteristics. A direct measurement is one that measures the actual critical physical characteristic, such as material hardness when material hardness is the critical characteristic. Because some physical characteristics are difficult to measure directly, validated indirect measurements may be necessary. These indirect measurements should encompass characteristics that are as close as possible to the critical physical characteristics. For example, vibration may be an indirect measurement of wear; elasticity, as measured by an elongation test, may be an indication of electrical insulation integrity. Visual observations, such as discoloration caused by heat and corrosion, may also be valid indicators of physical degradation. The observable parameter should have been validated as an accurate indication of the progress of a component or subcomponent to its point of failure. One or more observable parameters should be chosen to monitor each critical physical characteristic.

Finally, the measurable and observable parameters for each component are brought together into a list of practical measurements that can be performed to monitor significant aging effects. This list of practical measurements provides the basis for obtaining baseline MCA measurements of component material condition.

4.2.3.4 Baseline Measurements of Component Material Condition

Measurements should be made of significant aging effects to determine the current material condition of life-limiting components to establish a baseline for determining the remaining lifetimes. These measurements also form the basis for recommendations regarding periodic material condition monitoring and trending to anticipate the end of lifetime that might be implemented during the ongoing MCA phase.

4.2.4 DETERMINATION OF FACILITY REMAINING LIFETIME

The process for determining facility remaining lifetime is shown in Figure 4–6. The first task is to determine the current condition of the component or subcomponents as indicated by the baseline measurements plus the following historical considerations: time in service; usage or operational history; stressor history or, if unavailable, a conservative approximation that bounds expected extremes and maintenance and surveillance history.

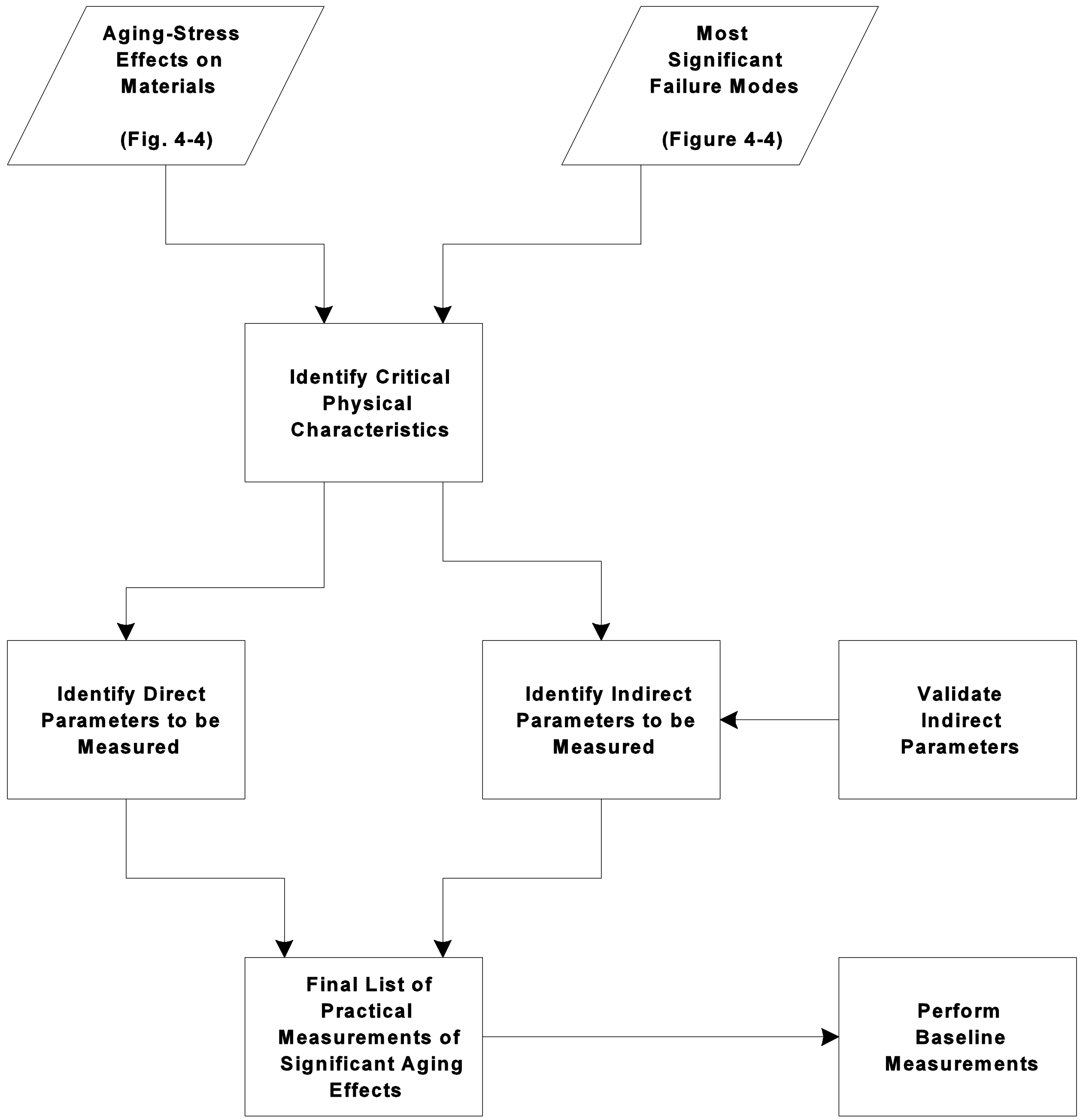
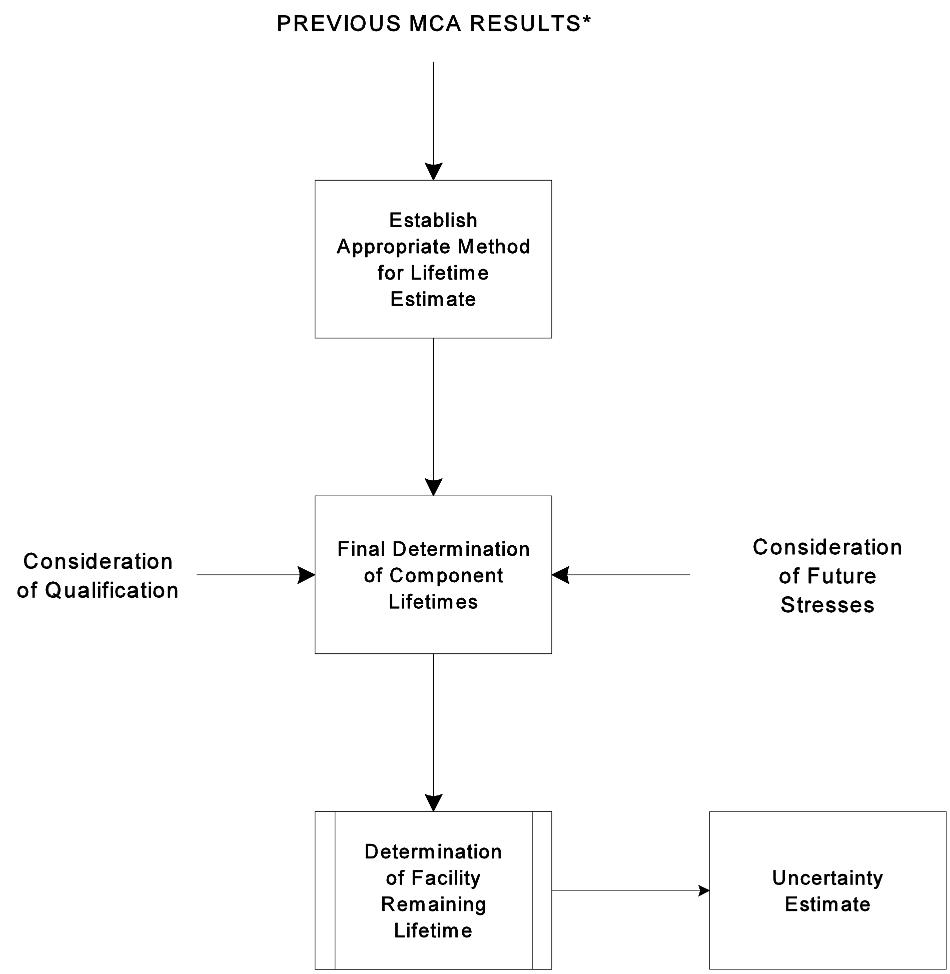


Figure 4-5. Identification of Material Condition Measurements



* Previous MCA Results

Preliminary Estimate of Remaining Lifetimes
Final List of Life-Limiting Components
Significant Aging Degradation Mechanisms
Baseline Measurements
Historical Use Considerations

Figure 4-6. Final Determination of Facility Remaining Lifetime

The next task is to select an appropriate method for estimating the component's remaining lifetime. In some cases, a simple time-in-service approach is sufficient. The remaining lifetime is calculated as the total lifetime of the component less the time that it has already been in service. For example, if the vendor indicates that a component should have a total lifetime of 15 years and that component has already operated at the facility for 11 years, its remaining lifetime is estimated to be 4 years. In other cases, the time-in-service approach is not adequate for estimating the remaining lifetime. It may be necessary to take into account the actual service history (e.g., the number of operating cycles and the stresses associated with each cycle), which may differ from the average service conditions anticipated by the vendor. An approximation of facility remaining lifetime should include consideration of the identified aging mechanisms and one or more of the following:

- Failure rates (mean time to failure)
- Comparison to components with similar materials and environmental history
- Straight-line projections utilizing current condition and projected degradation rates
- The Arrhenius model (applicable to materials that age as a function of the ambient temperature)
- Engineering judgment

Depending on whether future operations of life-limiting components are expected to have stresses that are similar to, greater than, or less than those experienced in past operations, it may be necessary to modify simple straight-line projections that begin with current condition and apply observed degradation rates to estimate remaining lifetime. Existing data that are useful in arriving at this estimate include operating and maintenance histories, occurrence of severe events that may have significantly stressed the component, industry experience with similar equipment, vendor specifications, and design information. This information may reveal a significant difference between the actual operating conditions and those assumed by the designer or the vendor which may provide the basis for adjusting the expected total life of a component.

The remaining lifetime is estimated by subtracting the time-in-service (modified as appropriate through current condition considerations, as discussed) from either qualified life, updated as necessary, or the expected total life. The remaining lifetime of the subcomponents determines the remaining lifetime of the component being assessed.

Determination of remaining lifetime should be conservative because of the uncertainties in the estimating process. The determination should take into account factors such as overall confidence level of estimated time to failure and frequency of monitoring the limiting age-related characteristics. The degree of the uncertainty should be estimated and included with the final determination of the remaining lifetime.

4.2.5 FEASIBILITY OF CONTINUED OPERATIONS AND EXTENDED OPERATIONS

After the previous conclusions concerning the feasibility of continued operations have been either confirmed or revised, management alternatives similar to those considered in earlier feasibility studies should be considered during the final feasibility study. The costs, as a function of time, of each alternative should be determined and presented. Significant break points in the cost factors should be identified and highlighted. The following cost factors should be considered:

- Present operating and maintenance costs (used as a reference for evaluating alternatives)
- Costs for continued operations, including those for accommodating both near-term and long-term continued operations, and any costs related to delays in completing the facility mission
- Costs to develop and implement facility upgrades needed for life extension
- Costs to enter and maintain standby operations, and then to restart the facility
- Costs of decommissioning the facility

There is a potential overlap between the feasibility studies conducted in this detailed MCA phase and the activities of the ongoing phase of the MCA program. If DOE has specified a desired lifetime for the facility that is significantly longer than the remaining lifetime, it is necessary to develop life extension techniques. When the need for life extension techniques is clear, they should be developed during this phase, at least to the extent that there is a basis for recommendation for life extension techniques for the ongoing MCA phase, and the costs of development and implementation of those techniques should be estimated and included In the feasibility study (to the extent that the costs of those techniques can be estimated).

Similarly, the feasibility study should include recommendations for periodic MCA monitoring of equipment, based on the measurements of the baseline material conditions used in the aging degradation evaluations, and for trending the results to predict the end of life for life-limiting components.

4.3 LIFE EXTENSION TECHNIQUES

Life extension techniques make it possible to operate a component beyond Its normal lifetime. Life extension techniques include actions that reduce stresses, such as operational changes and hardware/facility modifications, and those that reduce the effects of stresses. Generally, life extension techniques are applied only to components that have been determined to be life-limiting for the facility. The development and application of such techniques have associated costs, as estimated during the feasibility study. These costs should not be incurred unless DOE has specifically directed such expenditures or has specified a desired lifetime that is greater than the remaining lifetime of the facility.

Environmental stressors, such as temperature and radiation, which are known to induce aging degradation, particularly in non-metallic materials, can be characterized and their impact reduced to extend component life. Collection and evaluation of environmental data can provide the basis for adjustments to environmental conditions, such as by additional thermal insulation, venting of electrical enclosures, HVAC upgrades, the addition of radiation shielding, and periodic decontamination of piping near the equipment.

Adjustments in operational practices can extend component life. Such adjustments may include reducing the period of operation, decreasing the number and rate of startups/shutdowns, and optimizing or improving testing practices that contribute to equipment degradation.

Upgrading the design can also extend the lifetime. Equipment manufacturers and the commercial nuclear industry develop life-extending design enhancements based on operating experience and the availability of new technology/materials. These include changing to materials more resistant to aging stressors or reconfiguring for improved reliability. For example, during research conducted on electrical inverters, an evaluation of several design configurations demonstrated that the use of an automatic transfer switch improves the reliability of the power supplied to controls and equipment. Other recommended design improvements include the use of higher ratings for voltage- and temperature--sensitive components in the inverter circuitry, and the addition of forced-air cooling to reduce overheating problems.

4.4 ONGOING MCA PHASE

With the completion of the detailed or main MCA phase, the development of the MCA program is essentially complete. The ongoing MCA phase involves simply adapting previously developed MCA actions for incorporation into the ongoing CM program. For example, a one-time measurement method may be converted to a measurement method practical for repeated application, or life extension techniques needed to achieve the desired lifetime for the facility may be finalized.

Results of activities in earlier MCA phases should be forwarded as recommendations to the design authority for consideration as new design requirements. New design requirements should include actions related to periodic monitoring and trending of aging degradation, as well as actions related to life extension. To support these new design requirements, the aging degradation evaluations should also be provided as design basis. The appropriate line organizations, such as operations, or maintenance, carry out the approved new design requirements on an ongoing basis. For example, slower, stress-reducing operations (e.g., heatups, cooldowns) to extend facility lifetime are implemented through operations procedures. Periodic aging measurements may be performed by either the maintenance or system engineering organizations.

For the periodic monitoring, this involves fine-tuning the technical aspects of the periodic measurements for ease of use, error avoidance, and operational efficiency. In addition, it involves establishing appropriate frequencies for monitoring actions for different types of equipment, as well as requirements and methods for trending the results of those measurements and for extrapolating the trend to anticipate end of life. The resulting extrapolated lifetimes should be used to update the previously determined lifetimes.

4.4.1 DEGRADATION TRENDING

The purposes of degradation trending are to determine whether the degradations are progressing as expected and to identify corrective actions that may be necessary to achieve the component or facility lifetime. The analysis of data obtained by MCA periodic material condition measurements may show that component degradation is occurring faster or slower than expected. This new information may lead to revisions of the remaining lifetime determination, revising the life extension techniques, or some combination of both.

To ensure that the desired facility lifetime is achieved, it is necessary to monitor the components most likely to affect the facility lifetime, the components for which the lifetime is uncertain, and the components that need life extension techniques to achieve the desired facility lifetime. Consideration should also be given to adding measurements that are designed to detect unexpected degradation of the components. Often, it is the unexpected that causes a component to fail before the end of its life. For example, it was discovered in the commercial nuclear industry that thermal stratification of the liquid inside pipes connected to pressurizers can cause stresses in the pipe wall that can lead to failure. Yet, these stresses had not been anticipated in the design process. The final selection of measurements should take into account the significant failure modes, degradation mechanisms that could cause unexpected failures, and the practicality of obtaining these measurements.

The baseline measurements of the current condition of included components identify techniques that successfully measured critical physical characteristics and those techniques that did not. The baseline measurements show where improved or alternate measurement techniques are needed.

A list of potential measurements is then developed. These are termed "potential measurements" for two reasons: (1) more measurements may have been identified than are actually necessary (in some cases, the initial baseline results do not warrant repeating the measurements on a periodic basis); or (2) the total number of measurements may not be consistent with the overall capability of the facility for obtaining and analyzing the volume of information that will result from these repeated measurements over the long term. Also, alternative or improved measurement techniques may be identified that have not been previously obtained at the facility. It will be necessary to confirm that these techniques are consistent with the existing capabilities of the facility or that needed upgrades to the facility's measurement capabilities are feasible.

A final list of periodic material condition measurements should be developed based on the results of facility remaining lifetime determination, the previous baseline measurements, and the capabilities of the facility. In addition, consideration should be given to establishing measurement methods that can reasonably be expected to provide consistency and repeatability among different personnel across a period of several years.

Various monitoring methods, including continuous monitoring or scheduled inspections, provide periodic material condition measurements that determine current performance or condition. Observed values are then compared with minimum acceptance criteria and with results of previous observations on the same components. Criteria can be established so that corrective action is initiated when monitored parameters deteriorate to a specified level or vary in a specified manner.

Equipment monitoring does not always uncover aging degradation. For example, electronic components tend to fail catastrophically at random times, rather than degrading slowly over time in service. For this type of equipment, trending component failure rates may be the only appropriate method of monitoring aging. If sufficient statistical data are available, it is possible to schedule surveillance, preventive maintenance, or replacement more effectively. For example, if the failure pattern of a component shows that the probability of failure increases significantly after a certain time, replacement of equipment may be scheduled. This type of trending entails a systematic collection and analysis of operational data. The recording of equipment deficiencies in a specified, systematic manner makes it possible to determine the severity of failures, failure modes, and root causes of failures, and to monitor trends of failures and their causes.

4.4.2 APPLICATION OF LIFE EXTENSION TECHNIQUES

If the need for life extension techniques was apparent at the time of the detailed phase of the MCA program, the feasibility study should have included recommendations for life extension techniques, at least the preliminary development of those techniques, and estimates of the costs involved. That study should be used as the starting point for the ongoing phase of the MCA program. If life extension techniques have not been developed, or a new need for them should arise, they would be developed during the ongoing MCA phase.

During the ongoing phase, the life extension techniques are finalized and established as new requirements. Because these techniques often involve new design requirements, such as operating conditions or operational limitations for equipment, design authority is the appropriate organizational unit to review proposed life extension techniques. The operations organization staff also need to be involved in many situations to develop appropriate practical operating scenarios. In addition, the design authority should coordinate with the maintenance department to determine appropriate actions to be taken with regard to MCA for selected non-life-limiting components.

4.5 SPECIFIC APPLICATION OF GRADED APPROACH: MCA ADJUNCT PROGRAM

SSC grades are not significant to the main thrust of the MCA adjunct program. The MCA program is focused on life-limiting components, which can include components of any grade. This approach is necessary to arrive at a viable determination of the facility remaining lifetime. Other graded-approach considerations that are generally applicable to implementation of the MCA program are remaining/desired lifetime, operational status, and facility life-cycle phase. Remaining/desired lifetime and operational status generally have the greatest effect on determining the appropriate level of implementation. Depending on these considerations, MCA program implementation may include all the activities that have been described, or only a few.

The following matrix illustrates different implementation levels, identified as High, Medium, Low, and Minimal. The primary influence on selection of implementation level is the facility grade. There is, however, a secondary influence that involves the desired and remaining lifetimes. For facilities where the estimated remaining lifetime Is less than the desired lifetime, a high level of implementation is the most appropriate level of implementation. For facilities where the estimated remaining lifetime is about equal to the desired lifetime, a medium or low level of implementation may be appropriate. For facilities where the preliminary estimate of remaining lifetime is significantly greater than the desired lifetime and the facility grade is low, a minimal level may be most appropriate.

,As shown in the matrix, the activities related to estimating the facility remaining lifetime are needed for all facilities, because this input is so important to the overall CM program planning. The matrix applies when no other graded-approach consideration (e.g., facility technical type, operational status) has adjusted the program activities. When other graded-approach considerations indicate that an adjusted MCA program is appropriate, additional options may be used to tailor the MCA program to the facility needs. The matrix then serves as an example of relative importance.

IMPLEMENTATION MATRIX FOR MCA ADJUNCT PROGRAM				
MCA FUNCTIONS	HIGH	MEDIUM	LOW	MINIMAL
COMPONENT SCREENING	Necessary	Necessary	Necessary	Necessary
AGING DEGRADATION EVALUATIONS	Necessary	Necessary	Necessary	Necessary
ESTIMATION OF FACILITY REMAINING LIFETIME	Necessary	Necessary	Necessary	Necessary
FEASIBILITY OF CONTINUED OPERATIONS OR EXTENDED OPERATIONS	Necessary	Necessary	Recommended	Optional
DETAILED MCA ANALYSIS				
Component Screening	Necessary	Necessary	Recommended	Optional
Aging Degradation Evaluations	Necessary	Necessary	Recommended	Optional
Definition of Physical Characteristics and Measurements	Necessary	Necessary	Recommended	Optional
Baseline Measurements	Necessary	Necessary	Recommended	Optional
Facility Remaining Lifetime Determination	Necessary	Necessary	Recommended	Optional
Feasibility of Continued Operations or Extended Operations	Necessary	Recommended	Optional	Optional
DEGRADATION TRENDING, AGING MANAGEMENT, AND LIFE EXTENSION				
Establish Monitoring Requirements	Necessary	Recommended	Optional	Optional
Trend Data and Update Lifetime Determinations	Necessary	Recommended	Optional	Optional
Life Extension Techniques	As Necessary	As Necessary	As Necessary	As Necessary